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Patentanmeldung Nr. Patent application No. Demande de brevet n°

02388002.4

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

A method of producing large body fibre reinforced structural elements

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Applicant: **Fiberline A/S**

Title: **A method of producing large body fibre reinforced structural elements**

The present invention relates generally to the technique of producing large body fibre reinforced structural elements and in particular a technique of fixating bolt fixtures or bolts in the fibre reinforced structural element.

In the present context, the term a fibre reinforced structural element is construed as a general term comprising any structural element made from resin or plastics based materials being fibre reinforced by means of fibres such as glass fibre, carbon fibre or kevlar fibre reinforced structural elements produced from a resin material such as polyester, vinyl ester, phenol or epoxy. Further the structural element may in itself constitute a load-carrying element or a supporting element such as an element of a building structure, a facade element, a bridge, a component of a wind mill, a component of a ship such as a deck component.

Within the industry the use of fibre reinforced structural elements has increased rapidly within the last decades, basically inspired by the success of the use of such elements within the wind mill industry. Apart from wind mill components such as the blades of a wind mill, fibre reinforced structural elements have also gained success within the house-building industry and ship-building industry and even within certain technical fields in which metal structures have conventionally been used. As an example within the chemical industry or the galvanising- and zinc coating industry, conventional metal structures tend to have a fairly short life time due to the excessive corrosion impact whereas fibre reinforced structural elements including containers, stairs, supporting elements, etc. may stand the exposure to the corrosive atmosphere without being to any substantial extent deteriorated or ruined.

Examples of structural elements and techniques of fixating various components within structural elements are described in the below patent applications and patents to which reference is made and which US patents are hereby incorporated in the present application by reference. The reference comprises EP 0 370 695 US

It has been realised by the applicant company that the technique of embedding and fixating bolt fixtures and/or bolts within a fibre reinforced element may impose certain problems in particular as far as the proper and accurate location of the bolt fixtures or bolts are concerned. Whereas the conventional technique has involved the simple positioning of bolt fixtures or bolts within the fibre reinforced structural element to be machined, extruded or pulltruded in the production process, it has been realised by the applicant company that this conventional and simple technique does not allow the bolt fixtures or bolts to be positioned with the necessary accuracy needed within the industry and being a mandatory provision for the further commercial exploitation of the fibre reinforcing technique for the manufacture of structural elements.

An object of the present invention is to provide a novel technique allowing a simple and accurate positioning of bolts or bolt fixtures within a fibre reinforced structural element at predetermined positions or locations and with an accuracy acceptable within the industry including the house-building, ship-building and wind mill industry such as an accuracy of +/- 1mm variation of the location of a specific bolt or bolt fixture or even a lower variation such as a variation of +/- 0,5mm.

It is a feature of the present invention that the novel technique according to the present invention provides an improved transmission of force and impact to and from the fibre reinforced structural element through the bolt fixtures or bolts thereby allowing a reduction of the size of the fibre reinforced structure i.e. providing a reduction of the weight of the fibre reinforced structure or in the alternative a reduction of the materials used for the fibre reinforce structural element.

It is a further feature of the present invention that the method and technique according to the present invention allows bolt fixtures or bolts to be located at specific locations and fixated within a fibre reinforced structural element in solid and high-load bearing casing.

It is a particular advantage of the present invention that the novel technique of positioning and fixating bolt fixtures or bolts within a fibre reinforced structural

element allows the use of high-load bearing casings for the positioning of the bolt fixtures or bolts and to provide an easy positioning of the bolt fixtures and bolts in specific geometrical configuration or shape generated by particularly configurating the load-bearing casing supporting the bolt fixtures or bolts.

The above object, the above features and the above advantage together with numerous other objects, advantages and features which will be evident from the below detailed description of the present invention are according to a first aspect of the present invention obtained by a method of producing a fibre reinforced structural element including a plurality of bolt fixtures or bolts for the fixation of the structural element to another structural element, comprising the steps of:

i) providing an elongated core element of material, preferably fibre reinforcement material compatible with the materials of the fibre reinforced structural element, preferably made through pulltrusion, having an end part for the mounting or fixation of one of the bolt fixtures or bolts,

ii) mounting the one bolt fixture or bolt on the end part of the core element for producing a subassembly,

iii) fixating the one bolt fixture or bolt to the end part of the core element in a pulltrusion process by pulling the subassembly through a pulltruder, by circumferentially covering the subassembly with reinforcing fibres and resin and by heating and curing the resin for causing the resin to provide in conjunction with the reinforcing fibres a casing circumferentially encircling the subassembly, or alternatively fixating the subassembly by adhesion to the encasing produced in a separate pulltrusion process,

iv) machining the subassembly circumferentially encircled within the casing of the reinforcing fibres and the cured resin for providing a bolt fixture or bolt assembly including the core element and the one bolt fixture or bolt and the core element,

v) repeating the steps i-iv for producing a plurality of the bolt fixtures or bolt assemblies,

vii) producing the fibre reinforced structural element including the plurality of bolt fixtures or bolts constituted by the pluralities of assemblies in an extrusion, a pulltrusion or a fibre reinforcing production technique.

According to the basic teachings of the present invention, the individual bolt fixture or bolt is pre-positioned in a casing within a bolt fixture or bolt assembly. The assembly itself is composed of a core element which is accurately positioned relative to the bolt fixture or bolt and in a separate production process step fixated to the bolt fixture or bolt in a pulltrusion process. As will be described in greater details below, the use of the pulltrusion process for the production of the bolt fixture or bolt assembly allows the bolt fixture or bolt assembly to be manufactured in a specific metrical configuration promoting or ensuring the intentional positioning of the individual bolt fixtures or bolts within the final fibre reinforced structural element. The production of the bolt fixture or bolt assembly also ensures the necessary load-bearing capability of the individual bolt fixture or bolt due to the pulltrusion process used for the fixation of the bolt fixture or bolt relative to the core element within the individual blot fixture or bolt assembly.

The individual core element may be prefabricated e.g. through casting, machining, etc. from a material which is compatible with the materials of the fibre reinforced structural element meaning that the materials used for the core element and also for the pulltrusion process for the encasing of the subassembly comprising the bolt fixture and bolt and the core element are mechanically, structurally and chemically combinable with the materials of the fibre reinforced structural element. For most applications, the above described fibre reinforcing materials and resin materials are used and for obvious reasons, the bolt fixture or bolt assembly may be manufactured from materials compatible with the remaining materials of the fibre reinforced structural elements, however exhibiting improved strengths and load-bearing capability. Alternatively, the same materials may advantageously be used for the production of the bolt fixture or bolt assembly and for the remaining part of the fibre reinforced structural element.

Provided a none-pre-cast core element is used, the method according to the present invention preferably comprises the step of cutting the elongated core element from a continuous elongated core element body preferably made as already stated through pulltrusion.

The technique of mounting the one bolt fixture or bolt on the one end part of the core element may be easily accomplished provided the core element be configurated including a recess, a bore or having a protruding part such as a fitting configurated for the reception of the bolt fixture or bolt. In this context it is to be understood that the terms bolt fixture and bolt are used as genetic terms including elements such as the shaft of the bolt itself, a fitting including an internal thread or a differently configurated body including a protruding outer thread part or an inner thread for receiving the thread of a bolt. According to a particular advantageous embodiment of the method according to the present invention, the elongated core element is provided with respective end parts for receiving a total of two bolt fixtures or bolts at opposite ends of the core element and the method according to the present invention consequently also comprises in steps ii) and iii) mounting and fixating two bolt fixtures or bolts at the respective end parts of the core element of the subassembly and comprises in step iv) machining the subassembly circumferentially encircled within the casing of the reinforcing fibres and the cured resin into two halves each constituting a bolt fixture or bolt assembly.

According to a still further advantageous embodiment of the method according to the present invention, the proper fixation and orientation of the bolt fixture or bolt relative to the core element is obtained by machining the end part of the core element into a conical configuration and providing the bolt fixture or bolt having a conical end recess configurated in conformity with and congruent with the conical configuration of the end part of the core element, thereby providing an accurate and self-centering positioning and maintenance of the bolt fixture or bolt relative to the core element before and while performing the pulltrusion process in step iii).

bolt fixture or bolt of the assembly may be produced in a specific configuration through the pulltrusion process as the casing may be produced having a specific cross-sectional configuration such as a circular, an elliptical, a polygonal, in particular a hexagonal or square cross-sectional configuration or alternatively a cross-sectional configuration including oppositely positioned convex and concave surfaces.

Alternatively, the intentional geometrical configuration of the casing may be obtained by a separate machining step in which the casing is machined into a specific cross-section or configuration such as a circular, an elliptical, a polygonal, in particular a hexagonal or square cross-sectional configuration or alternatively a cross-sectional configuration including oppositely positioned convex and concave surfaces.

In a first embodiment of the method according to the first aspect of the present invention, the machining performed in step iv) is carried out by simply cutting vertically through the string of material provided from the pulltrusion process and the bolt fixture or bolt assembly is consequently provided having an end surface opposite to the bolt fixture or bolt fixated to the core element of the assembly extending perpendicular to the longitudinal axis of the bolt fixture or bolt assembly. According to the presently preferred embodiment of the method according to the first aspect of the present invention, the assembly is, however, provided in the machining process having a surface part defining an acute angle relative to the longitudinal axis of the bolt fixture or bolt assembly for providing a large surface of contact of the core element for fixating the assembly within the fibre reinforced structural element, and further for providing a none-rotationally symmetrical assembly which is optimally configurated for fixation within the fibre reinforced structural element.

The above object, the above features and the above advantage together with numerous other objects, advantages and features which will be evident from the below detailed description of the present invention are according to a second aspect of the present invention obtained by a method of producing a bolt fixture or bolt assembly for use in a fibre reinforced structural element including a plurality of bolt

fixtures or bolts for the fixation of the structural element to another structural element, comprising the steps of:

i) providing an elongated core element of material, preferably fibre reinforcement material compatible with the materials of the fibre reinforced structural element, preferably made through pulltrusion, having an end part for the mounting or fixation of one of the bolt fixtures or bolts,

ii) mounting the one bolt fixture or bolt on the end part of the core element for producing a subassembly,

iii) fixating the one bolt fixture or bolt to the end part of the core element in a pulltrusion process by pulling the subassembly through a pulltruder, by circumferentially covering the subassembly with reinforcing fibres and resin and by heating and curing the resin for causing the resin to provide in conjunction with the reinforcing fibres a casing circumferentially encircling the subassembly, or alternatively fixating the subassembly by adhesion to the encasing produced in a separate pulltrusion process, and

iv) machining the subassembly circumferentially encircled within the casing of the reinforcing fibres and the cured resin for providing a bolt fixture or bolt assembly including the core element and the one bolt fixture or bolt and the core element.

The method according to the second aspect of the present invention may according to the teachings of the present invention advantageously comprise any of the features described and discussed above in relation to the method according to the first aspect of the present invention.

The above object, the above features and the above advantage together with numerous other objects, advantages and features which will be evident from the below detailed description of the present invention are according to a third aspect of the present invention obtained by a fibre reinforced structural element including a plurality of bolt fixtures or bolts for the fixation of the structural element to another

and including a plurality of bolt fixture or bolt assemblies produced in accordance with the method according to the second aspect of the present invention.

The above object, the above features and the above advantage together with numerous other objects, advantages and features which will be evident from the below detailed description of the present invention are according to a fourth aspect of the present invention obtained by a bolt fixture or bolt assembly for use in a fibre reinforced structural element being produced in accordance with the method according to the second aspect of the present invention.

The present invention is now to be further described with reference to the drawings, in which

Fig. 1 is a partly sectional, perspective and schematic view of a first and presently preferred embodiment of an assembly from which two bolt fixture or bolt assemblies is produced.

Fig. 2 is a schematic and perspective view illustrating a first step of a method of producing the assembly shown in Fig. 1 including machining a pulltruded body into a plurality of core elements,

Fig. 3 is a schematic and perspective view illustrating a second step of the method of producing the assembly shown in Fig. 1 including mounting bolt fixtures at opposite ends of the core element produced in the step shown in Fig. 2,

Fig. 4 is an overall perspective and schematic view illustrating a third step of the method of producing the assembly shown in Fig. 1 constituting a process of providing in a continuous pulltrusion process a body from which the assembly shown in Fig. 1 is cut as is illustrated in the right-hand part of Fig. 4,

Fig. 5 is a schematic view illustrating a step of cutting the assembly shown in Fig. 1 and in the right-hand part of Fig. 4 into two bolt fixture assemblies,

Fig. 6 is a vertical sectional view illustrating the assembly shown in Fig. 1 and the bolt fixture assemblies produced from the assembly as shown in Fig. 5,

Fig. 7 is a schematic view illustrating the intentional application of the bolt fixture assembly shown in Fig. 5 and 6 for the production of a major fibre reinforced

structure such as a wind mill element, a bridge part, a building element, the bolt fixtures being positioned along the arch of a circle,

Fig. 8 is a perspective and schematic view similar to the view of Fig. 7 illustrating a slightly modified embodiment of the bolt fixture assembly used for the production of a fibre reinforced element in which the bolt fixtures are positioned along a rectilinear track,

Fig. 9 is a perspective and schematic view of a segment of a structural element produced from the assembly shown in Fig. 8 illustrating the fixture of the fibre reinforced structural element to an I-beam by means of bolts and knots, and

Fig. 10 is a perspective and schematic view illustrating the fixation of the fibre reinforced structural element produced from the assembly shown in Fig. 7 having the bolt fixtures positioned along the arch of a circle.

In Fig. 1, an assembly 10 is shown produced in accordance with the method according to the present invention and intended to be separated into two assemblies as will be described below with reference to Figs. 5 and 6.

According to the method of producing an assembly including a bolt fixture of bolt for use in a fibre reinforced structural element, a core element is initially produced. The core element may be produced form any relevant material including plastics based materials, wood or metal or composite materials which materials are compatible with the materials of the fibre reinforced structural element meaning that the materials of the core element like all other materials used in accordance with the technique of the present invention are combinable with the remaining materials i.e. do not react with one another in a chemical process, and a mechanically combinable or linkable meaning that the materials may be joined together in an integral structure and preferably exhibit substantial identical mechanical characteristics as far as coefficients of expansion, and mechanical strength such as tear and shear strengths are concerned. In accordance with the presently preferred embodiment of the method according to the present invention, a pultruded core body is preferably used as illustrated in Fig. 2.

In Fig. 2, a pulltruder is designated the reference numeral 30 in its entity and delivers from its output a pulltrusion rod 32 i.e. a rod of circular cylindrical cross-sectional configuration made from resin such as a polyester, vinyl ester or phenol or epoxy resin in which reinforcing fibres such as glass fibre, carbon fibre or kerval fibres are embedded. The pulltrusion rod or body 32 is cut into individual elements one of which is designated the reference numeral 12 by means of a cutter illustrated schematically as a saw 34. At opposite ends of the body or rod 12, conical end parts are produced by means of a machining device such as a cutter 36 illustrated schematically in Fig. 2. The cutter 36 produces the conical end parts designated the reference numeral 20 at opposite ends of the core body 12.

In a further step of the method of producing the assembly 10 shown in Fig. 1, bolt fixtures 22 are positioned at opposite ends of the core element 20 as is illustrated in Fig. 3.

Like the core element 12, the bolt fixtures 22 are preferably of a circular cylindrical cross-sectional configuration having at the one end a conical recess 20' configurated in conformity with the conical end part 20 of the core element 12. Each of the bolt fixtures 22 is further provided with a through-going bore communicating with the conical recess 20' and defining a narrow central cylindrical bore part 25 and a wider bore part 24 communicating with the exterior and intended to co-operate with a threaded shaft 28 as is illustrated in the lower left-hand part of Fig. 3. The bolt fixtures may be differently configurated as the bolt fixtures may e.g. be of an overall conical configuration tapering from the one end towards the other end e.g. from the outer end towards the inner end or from the inner end towards the outer end. Alternatively, the bolt fixtures 22 may be provided with outwardly pulltruding flanges. Further alternatively, the bolt fixtures may have a differently configurated through-going bore in which the threaded bore part communicates with the conical recess without the intermediate narrow cylindrical bore part. Further alternatively, the threaded bore may be omitted as the bolt fixture may be provided as a fixture having an outwardly pulltruding threaded shaft constituting a bolt.

By the provision of the co-operating conical end part and the conical recess 20' of each of the bolt fixtures 22, a self-centering and self-aligning feature is obtained as the bolt fixtures 22 due to the co-operation between the conical end part 20 and the conical recess 20' tend to be maintained in the intentional aligned orientation in which the circular cylindrical bolt fixtures 22 are constituting cylindrical continuations of the central part of the core element 12.

The subassembly comprising the core body and the two bolt fixtures 22 illustrated in Fig. 3 is, as is illustrated in Fig. 4, introduced into a pulltrusion apparatus 40 comprising a receiving section 46 in which the subassembly described above along with a plurality of subassemblies together constituting a continuous string is introduced into the receiving section 46 of the pulltrusion apparatus 40 together with webs of fibre reinforcing materials which webs are shown in the left-hand part of Fig. 4 and two of which are designated the reference numerals 42 and 44. From the receiving section 46, a string 48 including the aligned subassemblies circumferentially encircled by the fibre reinforcing materials is introduced into a resin applicator and resin heating and curing apparatus 50 communicating with a resin reservoir 52 for the supply of resin thereto. An output die of the apparatus 50 is designated the reference numeral 54 and provides a specific configurated shaping of the of a pulltrusion string 56 delivered from the die 54 apparatus 50 which string 56 is introduced into a puller apparatus 58 for pulling the pulltrusion string from the die 54 of the apparatus 50.

From the puller 58, the string 56 is delivered to a cutter 60 which separates the string 56 into distinct sections constituting the assembly 10 also shown in Fig. 1 as the cutting of the string 56 in the sections or assemblies 10 is synchronised with the entry of the subassembly comprising the core body 12 provided with the end part covering bolt fixtures 20 to the entry end of the pulltrusion apparatus 40. In an alternative process of producing the subassembly from which the assembly 10 shown in Fig. 1 is produced, the bolt fixtures 20 and the core element 12 are fixated

of fixating the bolt fixtures 22 and the core element 12 to the casing through the pulltrusion process are constituting technical equivalencies.

In Fig. 1, the core element 12 is shown together with the bolt fixture 22 disclosing the threaded bore 24 communicating with the bore 25 and further disclosing the tapering or conical end part 20 of the core element 12.

In Fig. 1, the outer casing produced in the pulltrusion process described above with reference to Fig. 4 is also disclosed, which casing is designated the reference numeral 26. Fig. 1 further discloses the particular advantageous configuration of the assembly 10 which configuration defines a concave top-surface 14, an opposite convex or circular cylindrical bottom surface 18 and opposite parallel planar surfaces 18. The convex/concave configuration illustrated in Fig. 1 allows, as will be described below with reference to Figs. 7 and 10, the positioning of the bolt fixture assembly produced from the assembly 10 by arranging the convex outer surface 16 or one bolt fixture assembly juxtaposed and partly received within the concave surface 14 of the adjacent bolt fixture assembly.

From the assembly 10 shown in Fig. 1, two bolt fixture assemblies are produced as is illustrated in Fig. 5 by cutting the assembly 10 into two parts along a line indicated in dotted line by the reference numeral 64. The cutter is schematically illustrated by a saw 62. The assembly 10 cut into two halves is illustrated in fig. 6 in a vertical sectional view disclosing the line of separation 64 providing opposite sloping surfaces 66 of each of the two bolt fixtures assemblies produced from the assembly 10. Each bolt fixture assembly constituting one half of the assembly 10 includes a tapering cut part of the core element 12 and the bolt fixture 22 fixated to the core element 12 by the pulltrusion encasing 26. By provision of the sloping surface 66 an irregularly shaped bolt fixture assembly is produced enhancing the ability of fixation of the bolt fixture assembly within the final fibre reinforce structure and further providing a major surface of contact between the central core element 12 and the final fibre reinforced structure.

The ability of positioning the individual bolt fixture assemblies in an orientation different from a rectilinear orientation is illustrated in Fig. 7 as three individual bolt fixture assemblies combined into a structure in its entity designated the reference numeral 70 is shown and including three bolt fixture assemblies positioned having the concave surface 14 of one bolt fixture assembly receiving in the convex surface 16 of the adjacent bolt fixture assembly in an overall angular orientation. The fibre reinforced structure encasing the composite structure shown in Fig. 7 is designated the reference numeral 72.

In Fig. 8, a slightly modified configuration of the bolt fixture assembly is illustrated as the circular concave and convex surfaces 14 and 16 are substituted by concave and convex outer surfaces having planar generators. By the planar generator configuration of the convex surface 14' having a configuration corresponding to the configuration of the convex surface 16' of the blot fixture assemblies, the individual bolt fixture assemblies may, as is illustrated in Fig. 8, be combined into a structure in which the proper rectilinear positioning of individual bolt fixture assemblies is ensured and maintained by the provision of the corresponding convex and concave surfaces of the bolt fixture assemblies. The combination of a total of four bolt fixture assemblies in Fig. 8 is in its entirety designated the reference numeral 70'. From the composite structure illustrated in Fig. 8, a fibre reinforced structural element is produced in a further extrusion, pulltrusion or manual or automated fibre reinforcing production process by the application of reinforcing fibres and resin to the combination of the fixture assemblies and configurating the structural element according to the intentional geometrical of the final product.

The final product is used e.g. as illustrated in Fig. 9 in connection with a load-bearing carrier I-beam 76 in which the bolt shafts 28 received within the bolt fixtures of the bolt fixture assemblies shown in Fig. 8 are fixated to the I-beam 76 by means of individual bolts 74.

Although the present invention has above been described with reference to specific, presently preferred embodiments, numerous modifications and amendments are obvious to a person having skill in the art and such modifications or amendments are to be considered part of the present invention without limiting the scope of the invention to the above described embodiments. Rather is the invention to be construed in the terms of the appending claims.

CLAIMS

1. A method of producing a fibre reinforced structural element including a plurality of bolt fixtures or bolts for the fixation of said structural element to another structural element, comprising the steps of:

i) providing an elongated core element of material, preferably fibre reinforcement material compatible with the materials of said fibre reinforced structural element, preferably made through pulltrusion, having an end part for the mounting or fixation of one of said bolt fixtures or bolts,

ii) mounting said one bolt fixture or bolt on said end part of said core element for producing a subassembly,

iii) fixating said one bolt fixture or bolt to said end part of said core element in a pulltrusion process by pulling said subassembly through a pulltruder, by circumferentially covering said subassembly with reinforcing fibres and resin and by heating and curing said resin for causing said resin to provide in conjunction with said reinforcing fibres a casing circumferentially encircling said subassembly, or alternatively fixating said subassembly by adhesion to said encasing produced in a separate pulltrusion process,

iv) machining said subassembly circumferentially encircled within said casing of said reinforcing fibres and said cured resin for providing a bolt fixture or bolt assembly including said core element and said one bolt fixture or bolt and said core element,

v) repeating said steps i-iv for producing a plurality of said bolt fixtures or bolt assemblies,

vi) positioning said plurality of assemblies according to the intentional position of said plurality of bolt fixtures or bolts within said final fibre reinforced structural element, and

vii) producing said fibre reinforced structural element including said plurality of bolt fixtures or bolts constituted by said pluralities of assemblies in an extrusion, a pulltrusion or a fibre reinforcing production technique.

2. The method according to claim 1, said step i) of providing said elongated core element comprising the step of cutting said elongated core element from a continuous, elongated core element body.

3. The method according to any of the claims 1 and 2, said elongated core element having respective end parts for receiving a respective bolt fixture or bolt at said respective end parts, said steps ii) and iii) comprising mounting and fixating two bolt fixtures or bolts at said respective end parts of said core element of said subassembly, and said step iv) comprising machining said subassembly circumferentially encircled within said casing of said reinforcing fibres and said cured resin into two halves each constituting a bolt fixture of bolt assembly.

4. The method according to any of the claims 1-3, said step i) further comprising the step of machining said end part into a conical configuration for the receiving and centring of said bolt fixture or bolt having a conical end recess congruent with said conical configuration of said core element.

5. The method according to any of the claims 1-4, said casing being produced in step iii) having a specific cross-sectional configuration such as a circular, an elliptical, a polygonal, in particular a hexagonal or square cross-sectional configuration or alternatively a cross-sectional configuration including oppositely positioned convex and concave surfaces.

6. The method according to any of the claims 1-5, said step iv) further comprising the step of machining said casing into a specific cross-sectional configuration such as a circular, an elliptical, a polygonal, in particular a hexagonal or square cross-sectional configuration or alternatively a cross-sectional configuration including oppositely positioned convex and concave surfaces.

7. The method according to any of the claims 1-6, said step iv) comprising the step of providing said bolt fixture or bolt assembly having an end surface part

8. A method of producing a bolt fixture or bolt assembly for use in a fibre reinforced structural element including a plurality of bolt fixtures or bolts for the fixation of said structural element to another structural element, comprising the steps of:

i) providing an elongated core element of material, preferably fibre reinforcement material compatible with the materials of said fibre reinforced structural element, preferably made through pulltrusion, having an end part for the mounting or fixation of one of said bolt fixtures or bolts,

ii) mounting said one bolt fixture or bolt on said end part of said core element for producing a subassembly,

iii) fixating said one bolt fixture or bolt to said end part of said core element in a pulltrusion process by pulling said subassembly through a pulltruder, by circumferentially covering said subassembly with reinforcing fibres and resin and by heating and curing said resin for causing said resin to provide in conjunction with said reinforcing fibres a casing circumferentially encircling said subassembly, or alternatively fixating said subassembly by adhesion to said encasing produced in a separate pulltrusion process, and

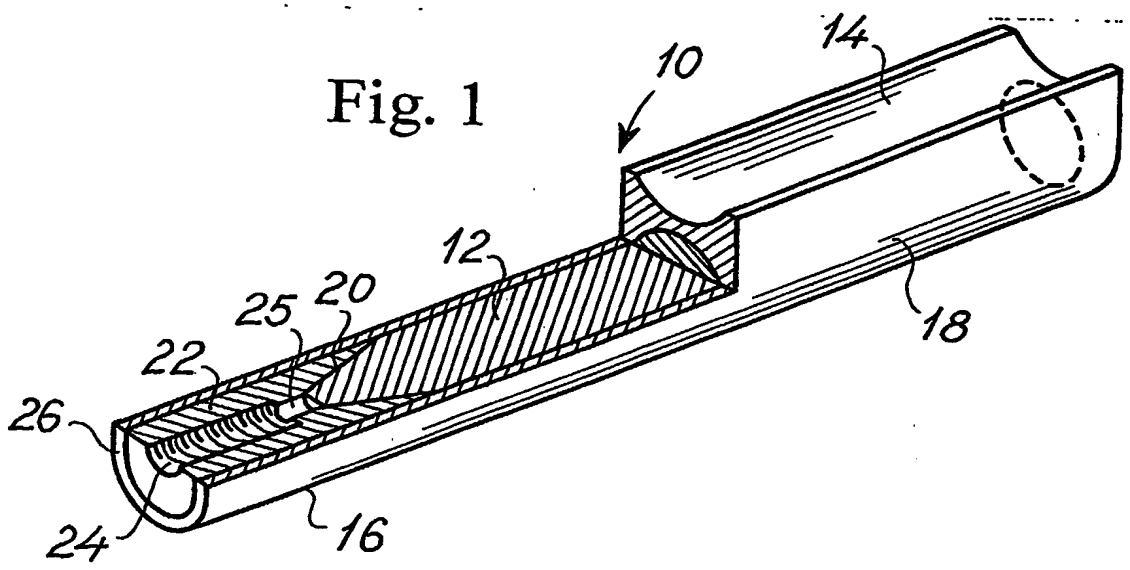
iv) machining said subassembly circumferentially encircled within said casing of said reinforcing fibres and said cured resin for providing a bolt fixture or bolt assembly including said core element and said one bolt fixture or bolt and said core element.

9. The method according to claim 8 of producing a bolt fixture or bolt assembly further comprising any of the features of the method of producing a fibre reinforced structural element according to any of the claims 2-7.

10. A fibre reinforced structural element including a plurality of bolt fixtures or bolts for the fixation of said structural element to another structural element, said fibre reinforced structural element being produced in accordance with the method according to any of the claims 1-7 and including a plurality of bolt fixture or bolt assemblies produced in accordance with the method according to any of the claims 8 or 9.

11. A bolt fixture or bolt assembly for use in a fibre reinforced structural element being produced in accordance with the method according to any of the claims 8 or 9.

Fig. 1



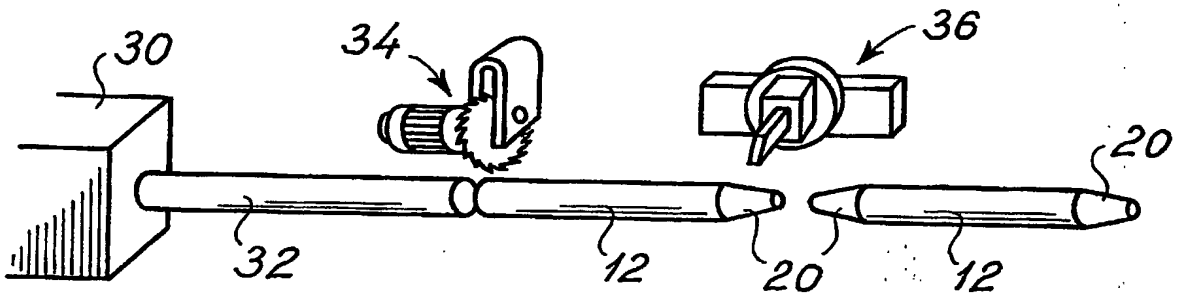


Fig. 2

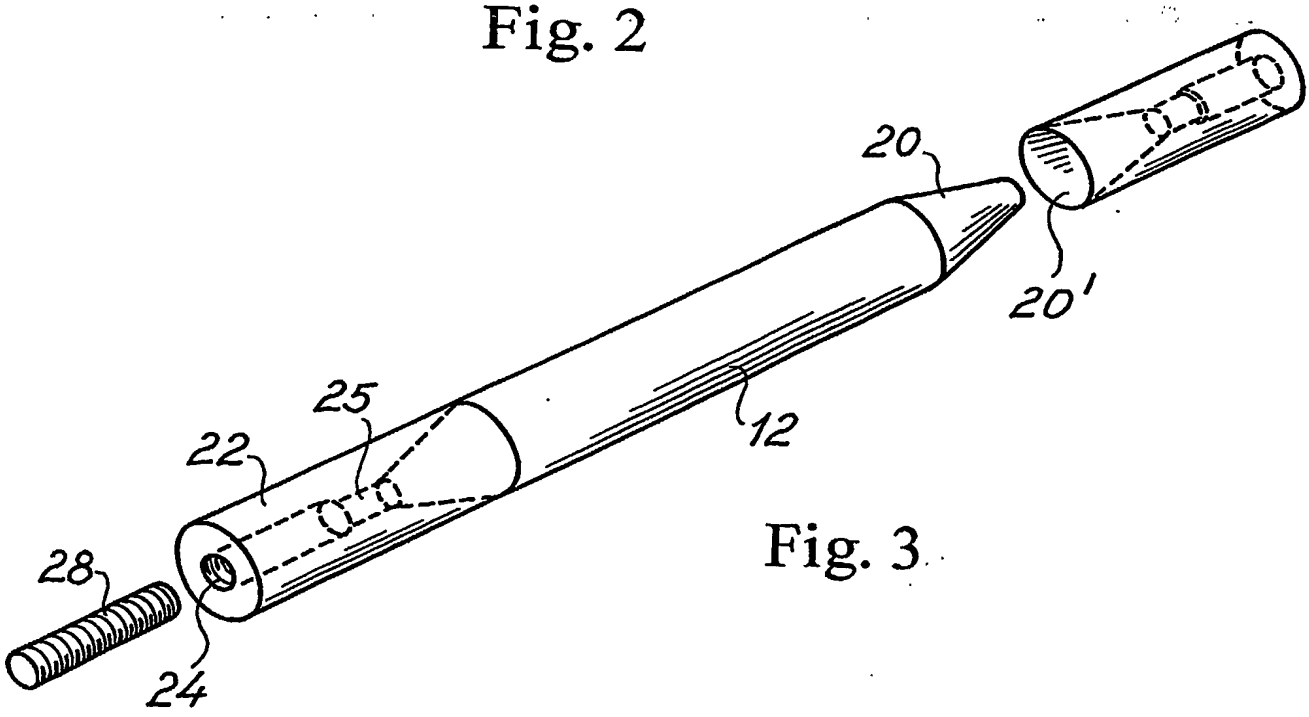


Fig. 3

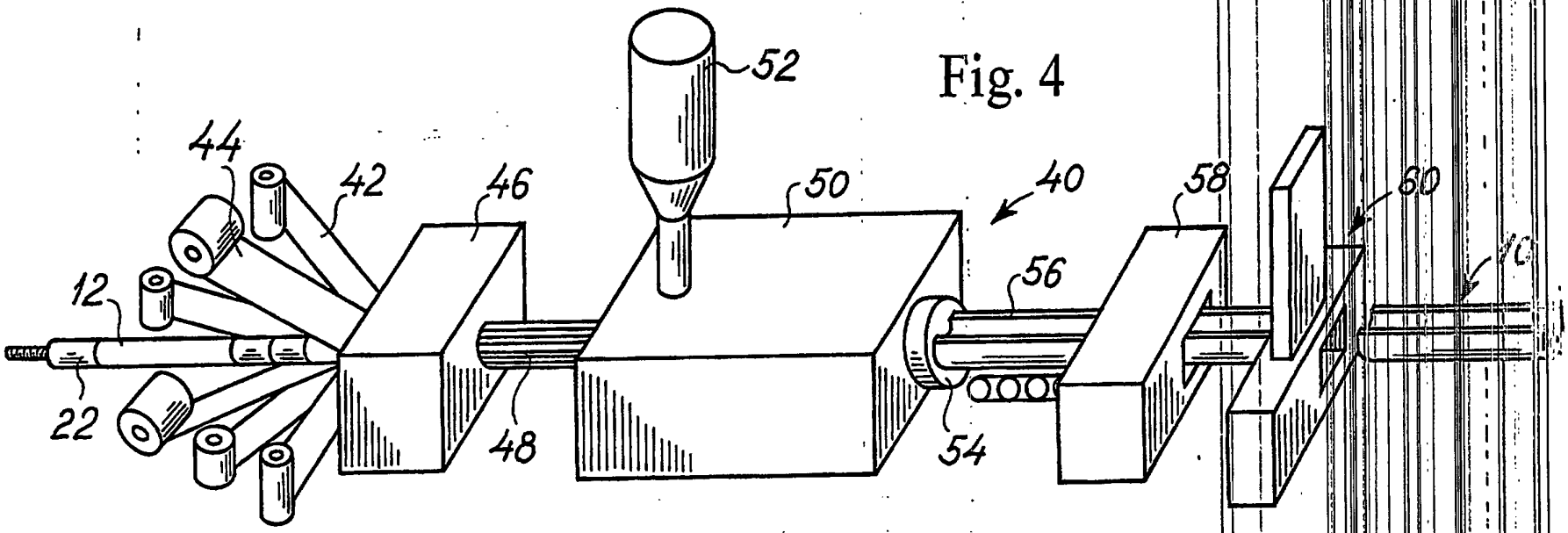


Fig. 4

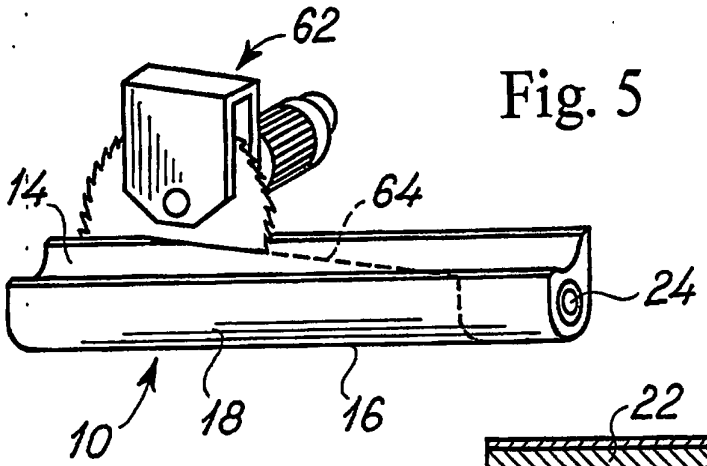


Fig. 5

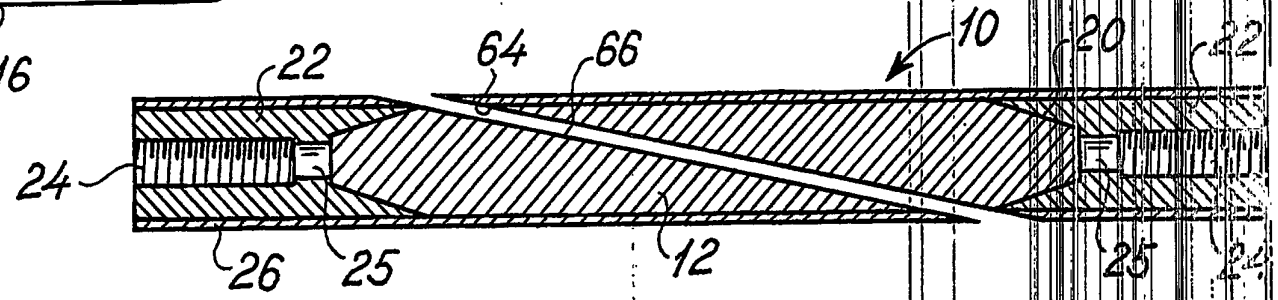


Fig. 6

Fig. 7

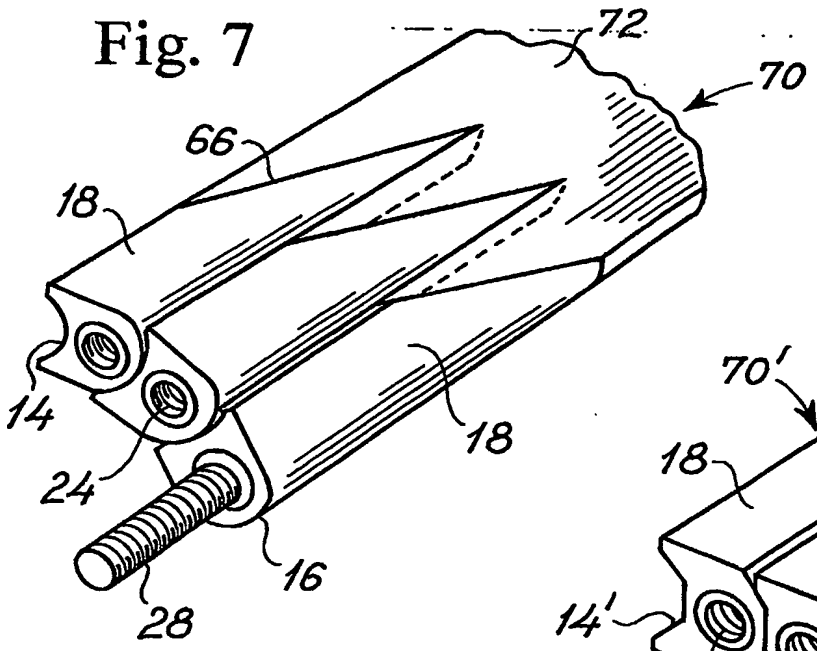
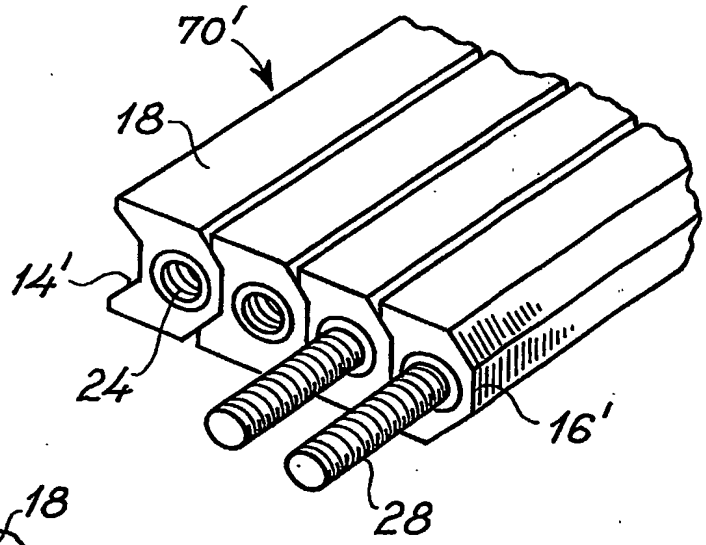


Fig. 8



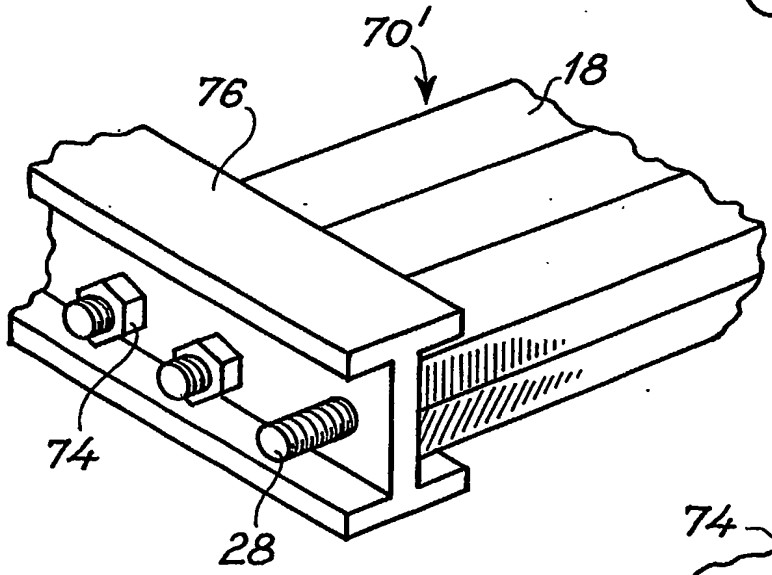


Fig. 9

Fig. 10